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As the below-named translator, I hereby declare that:

1. I certify that I am fluent in the English and German languages; and
2. The attached document is, to the best of my knowledge and belief, an accurate translation of German patent application DE 10 33 632.9, a copy of which is also attached.

TRANSLATOR:

Signature: ____________

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Certified translation from German into English

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Patent Application

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Method for the Manufacture of Rotationally Symmetrical Quartz Glass Crucibles and a Device for Implementation of the Method

The invention concerns a method for the manufacture of rotationally symmetrical quartz glass crucibles where an electric arc is produced by means of an electrode arrangement, consisting of one or several anodes and one cathode, and thus a wall or a section of the wall of the rotating quartz glass crucible being heated. Moreover, the invention concerns a device for implementation of the method.

A method and a device of the said type are frequently used in practice due to their great economic efficiency. For this, a melting form which is made to rotate is partly filled with SiO_2 grains, these being either natural or synthetic SiO_2 grains. By means of a template, a preform of the later quartz glass crucible is made from the grains during rotation. Thereafter, an electric arc is ignited by means of the electrode arrangement and guided along in different levels on the rotating wall of the quartz glass crucible, whereby the quartz glass grains are molten to a glassy wall in the form of the quartz glass crucible. After cooling the quartz glass crucible, its final form is already created with the inside of the wall being glazed while – on the outside of the wall – SiO_2 grains still adhere, which are abraded or sanded off in a subsequent process step. The outside is unglazed.

Such a method is also the subject of DE 197 10 672 A1 in which a layer-type structure with specific properties is made by additionally scattering in SiO_2 grains with other components.

It is of fundamental importance for the method that a specific rotational speed of the melting form is maintained, the speed being primarily defined by the geometric dimensions of the quartz glass crucible, because the resulting centrifugal forces keep the SiO_2 grains in the form preformed by means of the template. An insufficient rotational speed with correspondingly low centrifugal forces will result in the loose SiO_2 grains being unable to be kept in the desired position and partly sliding to the bottom in the melting form. In contrast, an excessive rotational speed will result in the bottom layer of the quartz glass crucible being displaced towards the outside, and breaking up in the process. Accordingly, the rotational speed is variable only to a very limited extent.

It proves to be disadvantageous that a sufficiently high and uniform heating of the wall, especially with large quartz crucibles, can only be reached by the electrode arrangement being run with great thermal output. However, on scattering the SiO_2 grains, evaporation phenomena and bubble formation may result which considerably deteriorate the quality of the final product. Moreover, the buildup rate of the inside layer is reduced (the result of major evaporations). Furthermore, partial heating of a section of the rotating wall causes a cooling-down phase equivalent to the duration of one full revolution until the section of the wall re-enters the heating zone whose duration – especially at low rotational speeds and large diameters of the quartz glass crucible – will result in great temperature variations and thus loss of quality.

In view of this background, the invention is based on the task of further developing a method of the type mentioned in the beginning such that – independent of the rotational speed of the rotating quartz glass crucible – the resulting temperature difference can be substantially reduced to be able to largely exclude, in particular, undesirable evaporations and bubble formation due to excess heating or cooling. Furthermore, a device for implementation of the method is to be provided.

The first task is met according to the invention by heating another section of the wall of the quartz glass crucible by at least one additional electrode arrangement. In this way, each individual electrode arrangement can be operated with reduced thermal

output. Accordingly, evaporation phenomena can be largely excluded, above all on scattering of the SiO_2 grains. Additionally, this method in connection with a geometrically pre-defined rotational speed significantly reduces the duration of the cooling-down phase until re-entry of a respective section of the wall into a subsequent heating zone of the next electrode arrangement. Accordingly, the occurring differences in temperature are greatly reduced. Simultaneously, the thickness of an inside layer created by scattering the SiO_2 grains can be increased, while the part of SiO_2 grains now evaporating with a higher thermal output according to the state of the art will be available to a larger extent for buildup of the inside layer. Moreover, there is no longer the need to suck off the evaporating parts of SiO_2 grains, so that the manufacturing process can be largely automated. Furthermore, this method shortens the duration of the manufacturing process, resulting in an improved utilization of the plant and thus an increase of economic efficiency.

An especially advantageous further development of the method is realized by heating via the electrode arrangement different sections which are at a distance from each other in the direction of the rotational axis of the quartz glass crucible. By means of the electrode arrangements provided for this purpose in a different vertical position, heat can be introduced over a large surface and the process duration can be shortened. At the same time, a more uniform heating of the quartz glass crucible with correspondingly improved quality is achieved.

The second task mentioned above, provision of a device for the manufacture of a rotationally symmetric quartz glass crucible through sectionally heating it by means of an electrode arrangement provided for the generation of an electric arc, comprising one or several anodes and one cathode, with the quartz glass crucible being rotatable around its axis of rotation, is met according to the invention by providing the device – in addition to the first electrode arrangement – with at least one additional electrode arrangement, consisting of one or several anodes and one cathode, which is inclined towards a section of the quartz glass crucible that faces away from the first electrode arrangement. In this way, the temperature of the quartz glass crucible can be kept at a comparatively high level independent of the rotational speed, so that

there occur significantly lower temperature differences. In this, a section of the surface – above all a wall or bottom section – heated by the electric arc of the first electrode arrangement will reach the heating zone of the electric arc of the second electrode arrangement already after insignificant change of the angle of rotation, which allows for operation of the individual electrode arrangements at a reduced thermal output. Because of the resulting reduction of evaporation phenomena, additional measures to suck off the evaporated particles are avoided, and the utilizable part of the scattered SiO_2 grains is increased so that quick buildup of an inside layer of considerably greater layer thickness is achieved. Furthermore, the resulting inside layer is essentially free of bubbles, so that stricter quality requirements can be easily met. Simultaneously, the reject rate of the manufactured quartz glass crucibles and the duration of the manufacturing process are reduced, resulting in an improved economic efficiency of the manufacturing process. Moreover, this method allows for the manufacture of crucibles of considerably larger diameter than the prior art.

In an especially advantageous embodiment of the invention, the electrode arrangements are arranged at different positions which are at a distance from each other in direction of the rotational axis of the quartz glass crucible. Thus, large-surface heating is implemented for example through a part or the total height of the wall of the quartz glass crucible to achieve uniform heating. This results in an increase in quality and in a reduction of the duration of the manufacturing process, and thus the manufacturing costs.

It is also especially advantageous to allow for independent moving of the electrode arrangements. In this way, optimum adaptation to the various forms of the quartz glass crucible can be achieved by the correspondingly matched distance to the wall. In this way, the quality achievable with the arrangement can be further improved, and especially complicated forms of a quartz glass crucible other than simple pot or cylinder forms, also with larger diameters, can be manufactured without any design changes to the arrangement.

For this purpose, a further development according to the invention is especially advantageous in which the electrode arrangements are arranged uniformly distributed with regard to the circumference of the quartz glass crucible. In this way, the cooling period of a wall section between two subsequent heating zones of the various electrode arrangements, which is defined by the geometric dimensions and the resulting rotational speed of the quartz class crucible, is kept constant, so that any undesirable temperature variations can be avoided. Therefore, this equipment of the device results in another increase in quality.

In another advantageous embodiment of the invention, at least one electrode arrangement is provided with a feed-in for SiO_2 grains, while at least one other electrode arrangement is exclusively intended for heating. In this way, a simplification of the device and its control is realized, one electrode arrangement being used exclusively for heating a section of the wall, while SiO_2 grains are additionally scattered into the electric arc of another electrode arrangement to build up an inside layer of the quartz glass crucible.

The invention provides for different embodiments. For further clarification of the basic principle, one embodiment is illustrated in the drawing and described in the following. The figure shows in a sectional side view a melting form 1 with a quartz glass crucible 2 inserted therein and being designed as a crucible. Above an opening 3 of the quartz glass crucible 2, there is positioned a device 5 equipped with a cooling body 4 in the form of a cooling plate, through which a first electrode arrangement 7 and another electrode arrangement 8 project into an interior space 6 of the quartz glass crucible 2. Each of such electrode arrangements 7, 8 – respectively equipped with one or several anodes 9 and one cathode 10 – after striking of an electric arc form one heating zone 11, 12 in the area of a wall 13 of the quartz glass crucible 2. In such heating zones 11, 12, one section 14, 15 of the wall 13 is heated, the heating period of each of the sections 14, 15 being defined by the rotational speed of the quartz glass crucible 2 rotating around a rotational axis 16. The rotational speed is in turn defined to a large degree primarily by the geometric dimensions of the quartz glass crucible 2, because the SiO_2 grains – at first lying loosely against the quartz

glass crucible 2 and then forming the resulting quartz glass crucible 2 – is kept in a form pre-formed by a template exclusively by the centrifugal force occurring on rotation. Here, an excess rotational speed of the quartz glass crucible 2 above all in the area of the bottom 17 of the quartz glass crucible 2 will lead to an undesirable displacement of the SiO_2 grains towards the outside, while an insufficient rotational speed will lead to the grains in the melting form 1 sliding to the bottom. By the provision of two electrode arrangements 7, 8, the duration of the cooling down-phase of one section 14, 15 between the subsequent heating zones 11, 12 is shortened, while the temperature different of the wall 13 is reduced. At the same time, the thermal output of each of the electrode arrangements 7, 8 can be reduced, so that there occurs only minor evaporation of components of the scattered SiO_2, resulting in a largely bubble-free final product.

List of reference numbers:

1	melting form
2	quartz glass crucible
3	opening
4	cooling body
5	device
6	interior space
7	electrode arrangement
8	electrode arrangement
9	anode
10	cathode
11	heating zone
12	heating zone
13	wall
14	section
15	section
16	rotational axis
17	bottom

Claims

1. A method for the manufacture of rotationally symmetric quartz glass crucibles wherein an electric arc is produced by means of an electrode arrangement, thus a wall or a section of a wall of the simultaneously rotating quartz glass crucible being heated, **characterized in that** by at least one additional electrode arrangement, an additional section of the wall of the quartz glass crucible is heated.

2. A method according to Claim 1, **characterized in that** – due to the electrode arrangement – different sections are heated which are at a distance from each other in the direction of the rotational axis of the quartz glass crucible.

3. A device for the manufacture of a rotationally symmetrical quartz glass crucible through sectionally heating it by means of an electrode arrangement provided for the generation of an electric arc, comprising one or several anodes and one cathode, with the quartz glass crucible being rotatable around its axis of rotation, **characterized in that** the device (5) - in addition to the first electrode arrangement (7) – is provided with at least one additional electrode arrangement (8), consisting of one or several anodes (9) and one cathode (10), which is inclined towards a section (15) of the quartz glass crucible (2), such section facing away from the first electrode arrangement (7).

4. A device according to Claim 3, **characterized in that** the electrode arrangements (7, 8) are arranged in different positions which are at a distance from each other in the direction of the rotational axis (16) of the quartz glass crucible (2).

5. A device according to Claim 3 or 4, **characterized in that** the electrode arrangements (7, 8) can be moved independently of each other.

6. A device according to at least one of the Claims 3 to 6, **characterized in that** the electrode arrangements (7, 8) are arranged uniformly distributed with regard to the circumference of the quartz glass crucible (2).

7. A device according to at least one of the Claims 3 to 6, **characterized in that** at least one electrode arrangement (7, 8) is provided with a feed-in for SiO_2 grains, while at least one other electrode arrangement (7,8) is exclusively intended for heating.

Summary

In a device (5) for the manufacture of a quartz glass crucible (2), one section (14, 15) of a wall (13) of the rotating quartz glass crucible (2) is heated at one time by means of at least two electrode arrangements (7, 8) distributed uniformly at the circumference of the quartz glass crucible (2) and generating a first and another electric arc. By providing several electrode arrangements (7, 8), the cooling-down phase of the sections (14, 15) until their reaching the subsequent heating zone (11, 12) can be shortened, and thus an undesirable high temperature difference of the wall (13) can be avoided. Moreover, the required thermal output of each individual electrode arrangement (7, 8) can be reduced, so that evaporation phenomena and connected bubble formation can be reduced. In addition to the higher quality that can be reached in this way, the duration of the manufacturing process is reduced.

(one single Figure)

As duly appointed and sworn translator for the English language by the President of the Regional Court Würzburg, I certify that the foregoing is, to the best of my knowledge and belief, a true and correct translation of the identical Original of the German document presented to me.

Würzburg, 31 July 2007

Susanne Kolbert
Sworn Translator

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